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Types of organic light-emitting diode (OLED)

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ABSTRACT

An organic light-emitting diode (OLED) consists of several semiconducting organic layers sandwiched between two electrodes, at least one of them being transparent. OLEDs can provide brighter, crisper displays on electronic devices and use less power than conventional light-emitting diodes (LEDs) or liquid crystal displays (LCDs) used today. OLEDs are made by placing thin films of organic materials between two conductors. When electrical current is applied, a bright light is emitted. The OLED materials emit light and do not require a backlight . Each pixel is a small light-emitting diode, in fact. OLEDs emit light they do not require a backlight and so are thinner and more efficient than LCD displays .In this paper we investigate the different types of OLEDs.

Keywords: OLED, Passive-matrix OLED, Active-matrix OLED , Transparent OLED, Top-emitting OLED , Foldable OLED, White OLED

INTRODUCTION

OLED is an emerging display technology that enables beautiful and efficient displays and lighting panels. Thin OLEDs are already being used in many mobile devices and TVs, and the next generation of these panels will be flexible and bendable. When we talk about flexible OLEDs, it's important to understand what that means exactly. A flexible OLED is based on a flexible substrate which can be plastic, metal or flexible glass. The plastic and metal panels will be light, thin and very durable - in fact they will be virtually shatter-proof. It is estimated that the first range of devices to use a flexible display won't be flexible at all. While the manufacturer may bend the display or curve it around a non-flat surface, the final user will not be able to actually bend the device. Still it will have several advantages: these displays will be lighter, thinner and much more durable compared to glass based displays.Second generation flexible OLED devices may indeed be flexible to the final user. Finally, when the technology is ready, we may see OLED panels that you can fold, bend or stretch. This may create all sorts of exciting designs that will enable large displays to be placed in a mobile device and only be opened when required.OLEDs can also be used to make white lighting panels. OLED is a diffuse area lighting source with unique characteristics. While OLED lighting is still in its infancy, many believe that flexible OLED lighting panels may provide designers with a new lighting source that will create stunning designs.[1]

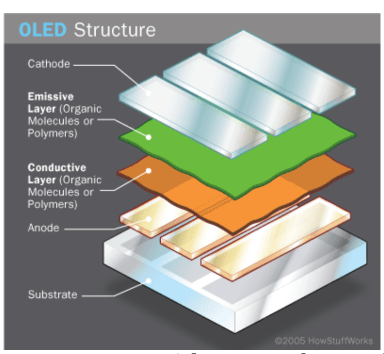

Fig 1: OLED structure (electronics.howstuffworks.com)

There are several different types of OLEDs:[2]

- Passive-matrix OLED
- Active-matrix OLED
- Transparent OLED
- Top-emitting OLED
- Foldable OLED
- White OLED

Passive-matrix OLED (PMOLED)

The PMOLED structure is arranged in a format that has rows and columns. There are columns of organic cathodes superimposed on rows of anode material. With this type of format, the row and column lines can be turned on to activate the individual pixels at the intersection points.

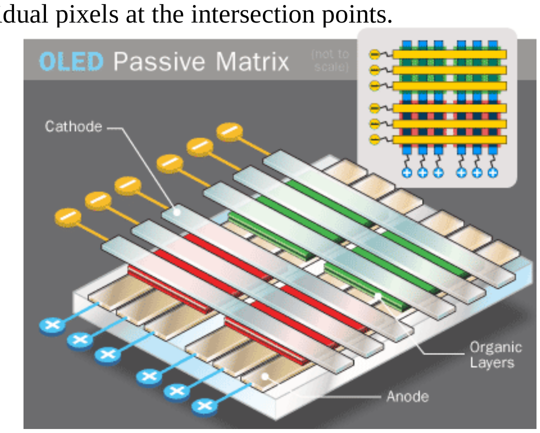

Fig 2: Passive-matrix OLED structure (electronics.howstuffworks.com)

The organic material is set down between the anode and cathode - with both the organic material and cathode metal regions being deposited using relatively standard processes. This enables large scale manufacturing to be achieved in a relatively cheap manner. In terms of their structure, the layers of organic material are set down in a form of ribbed structure with columns and rows obviously running in different directions. Although the concept of the PMOLED structure is relatively straightforward to design and fabricate, they require relatively complicated drive arrangements because each line needs to have the current limited for each diode this will change according to the number of diodes in a given row that are activated. In addition to this, the PMOLEDs require a significantly higher power consumption level than their active AMOLED counterparts. As a result PMOLEDs are normally most suited to display applications where the display size is less than about 50 mm to 80 mm across the diagonal or where there are less than about 100 rows.[3]

Active-matrix OLED (AMOLED)

Active-Matrix Organic Light-Emitting Diode (AMOLED) is a new display technology for mobile phones, televisions, and everything in between. AM (Active Matrix) refers to the display is addressed. Each pixel has an active element (a thin-film transistor, or TFT) that actively provides current to the OLED, maintaining that pixel's brightness while the other pixels are being addressed.

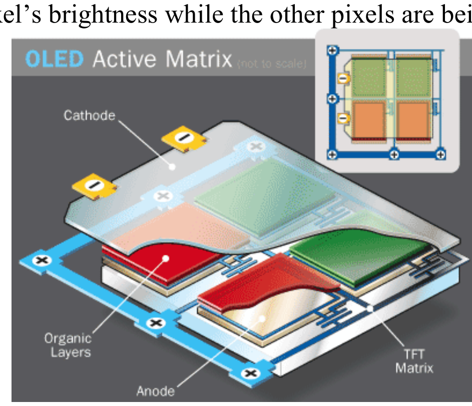

Fig 3: Active-matrix OLED structure (electronics.howstuffworks.com)

AMOLED displays are inherently simpler and have only two main layers:

Cross-section of an AMOLED display

1- An OLED (organic light-emitting diode) layer that emits light.

2- A backplane made of TFT (thin-film transistor) circuits that provide current to the OLEDs, thereby controlling their brightness.

There's usually a polarizer on top, which cuts reflected light. And that's it! The simpler structure will lead to lower cost than LCDs, in addition to being thinner and lighter.

AMOLEDs also have other advantages:

1- Lower Power: Only those pixels that are lit up consume power; dim screens (such as white text on a black background) consume almost no power, and video (where the pixels are only about 30% on) consumes much less power than LCD.

2- Higher Contrast: When a pixel is off, no light comes out all. This high contrast (over 100,000:1) gives stunning image quality

3- Better Viewing Angle: Because the light comes from the OLEDs on top of the display, the viewing angle is a true 180 degrees with no color shift

4- Richer Colors: The colors of the OLEDs are rich and deep, so the display looks much more vibrant than LCD [4]

Transparent OLED

Transparent OLED is a breakthrough transparent display technology that displays dynamic or interactive information on a transparent surface glass. This revolutionary display allows users to view what is shown on a glass video screen while still being able to see through it. Designers can overlay text, digital images, and video content onto physical objects or scenes that sit behind the glass. Transparent OLED displays are self-emitting and utilize cutting-edge Organic Light Emitting Diode (OLED) technology to eliminate the need for a backlight or enclosure, making it possible to create truly see-through installations in a virtually frameless glass design. Each pixel in a transparent OLED display is made up of 4 sub-pixels. Color is created by the combination of the red, green, and blue sub-pixels and the remaining area of the pixel is clear. That clear section creates the transparency.This is why there is a direct relationship between resolution and transparency. If the display contains more active pixels that creates less space for the clear pixels and results in a display that is less see through. This is why the Planar® LookThru™ OLED transparent display is Full HD resolution today, as it optimizes transmission and resolution. [5]

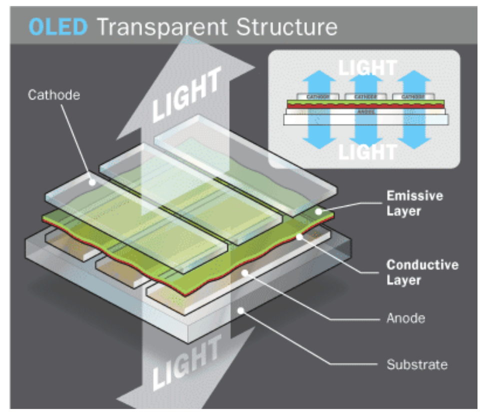

Fig 4: Transparent OLED structure (electronics.howstuffworks.com)

Transparent OLEDs have only transparent components (substrate, cathode and anode) and, when turned off, are up to 85 percent as transparent as their substrate. When a transparent OLED display is turned on, it allows light to pass in both directions. A transparent OLED display can be either active- or passive-matrix. This technology can be used for heads-up displays.

Advantage of transparent OLEDs [6]

Transparency: Capable of 70% to 85% transparency when turned off, TOLED pixels are nearly as clear as the glass or plastic substrate on which they are built. When used in an active-matrix OLED configuration, the effective transmission of the TOLED may, however, be somewhat reduced depending on the display resolution of the display and TFT design.

Bi-directional emission: Typically, the light generated by the TOLED emits from both surfaces. View a video. Enhancement films and other optical treatments may be used to direct more of the light in one direction than the other.

Performance: TOLEDs also offer excellent opto-electronic performance properties, i.e., spectral color emission, luminous efficiency and lifetime – that compare well to those for bottom-emission OLEDs

Top-emitting OLED

With the same proprietary cathode that is used for transparent OLEDs, TOLED technology can be employed for use in top-emitting OLEDs. Top-emission translates into two novel features. They are:

1- Improved active area and power consumption: Especially advantageous for high-resolution, active-matrix OLED applications, top-emitting structures can increase the effective active area of the display. This is achieved by directing emitted light away from — rather than through — the apertures of the thin film transistor (TFT) array that is on the bottom surface. In turn, with more effective active area, the power required to achieve a specific luminance level can also be reduced.

2- Use of opaque substrates: By emitting light through the top contact instead of the bottom contact (and substrate), TOLEDs have expanded the variety of substrate materials that can be used. Limited until now by their opacity, metallic foils and certain opaque polymer films have very desirable performance characteristics for OLEDs. View a video. In addition, TOLEDs can also be built on silicon wafers, especially desirable for miniature, high-resolution OLED display applications.

Recognized by many in the industry as a key technology enabler, our proprietary top-emission TOLED technology can open up a variety of new product and performance possibilities that can fuel future industry growth potential. [7]

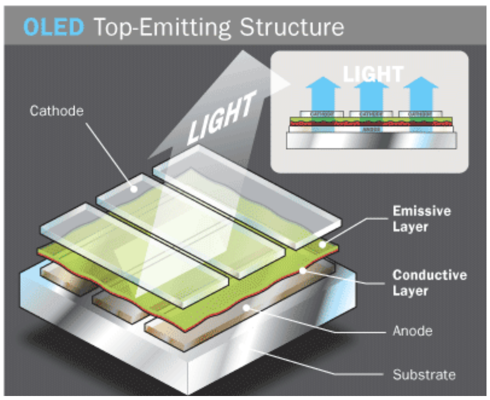

Fig 5: Top-emitting OLED structure (electronics.howstuffworks.com)

Foldable OLED

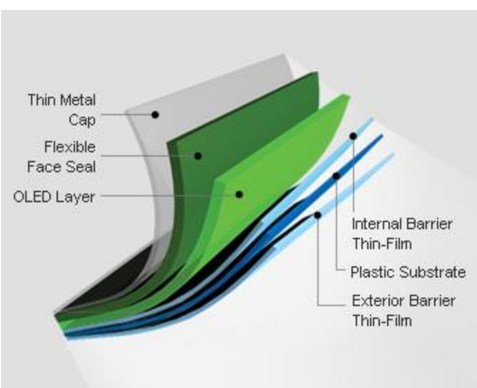

Fig 6: Foldable OLED structure (news.oled-display.net)

Organic light-emitting diodes (OLEDs) are supposedly the next big thing in display technology. In fact, over the years, several display makers have spent billions of dollars to build new and large OLED fabs. To be sure, OLEDs enable brighter displays, as compared to traditional LCD technology. OLEDs use a series of thin, light-emitting films, which enables the display to produce brighter light. OLEDs come in two forms–rigid and flexible. In fact, OLEDs promise to enable the long-awaited flexible display, which comes in foldable, rollable and stretchable forms. So far, though, OLEDs have only fulfilled some of their promises. OLEDs have yet to take off for large-screen TVs, as the manufacturing flow for the technology is complex and difficult. And LCD TVs, the competing technology, are cheap and relatively easy to make.

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White OLED

White organic light emitting diodes (white OLEDs) show promise for a major role in ambient lighting in the future. Low material costs, a wide choice of materials with customized properties, and easy production methods are features of the OLED technology which have favoured its fast development and industrial application in recent time. The energetically broad emission spectra and almost Lambertian emission of OLEDs are especially favourable for lighting applications, since they lead to homogeneous illumination and high quality color rendering. The possibility to produce large area OLED panels will also open new ways for lighting design apart from common incandescent bulbs or fluorescent tubes.[9]

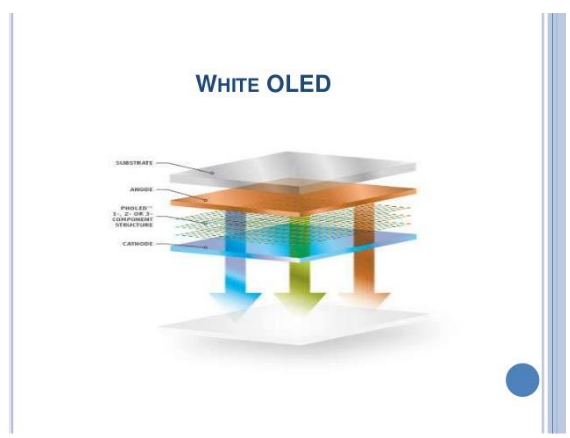

Fig 7: White OLED structure (www.slideshare.net)

Currently, the simultaneous maximization of device lifetime and efficiency of white OLEDs is most challenging and requires the development of new device strategies. Main focus is the combination of fluorescent blue dyes with phosphorescent green and red emitter systems in one OLED to get white light. We have developed a device concept which is most flexible and ready for the incorporation of various emitter systems with nearly arbitrary properties.

Key feature of this concept is an interlayer between phosphorescent and fluorescent regions with:

1- High triplet energy
2- High band gap 4-
3- Am bipolar transport properties

DISCUSSION

The LEDs in today's LED televisions are actually used only to provide a white back light, which then shines through a rapidly-refreshing LCD shutter array which tints the emanating light. OLEDs, on the other hand, operate as both light source and color array simultaneously. This may not sound like a big difference, but does offer a wide range of benefits including:[10]

1. Lower power consumption - An OLED display doesn't need any of the electronics and circuitry used to drive the LED back light and LCD shutter from a LED display, which makes OLEDs more efficient. LED screens produce black simply by fully closing the pixel shutter—the back light is still shining (it never actually turns off) but the light itself is being blocked. An OLED instead turns the pixel off entirely to produce the color black, saving energy in the process.

2. Better picture quality - Since OLEDs incorporate their own color filters, they can produce deeper blacks and a wider gamut array. The lack of a permanently-on backlight promotes higher contrast ratios (the difference between the brightest and darkest pixels on the screen). And thanks to the lack of a shutter array, OLED displays can have refresh rates that are an order magnitude faster than those of LCD/LED sets. We're talking a boost from 480 Hz to 100,000 Hz—theoretically, at least. On top of that, OLEDs offer an impressively wide viewing angle—nearing 90 degrees off center for many panels—without the color and clarity losses seen in traditional LEDs.

3. Better durability and lighter weight - Ditching the back light and shutter arrays also means manufacturers can replace the heavier, shatter-prone glass substrates often used in LED displays with lighter, stronger plastic substrates. And with the advent of injet-based printable OLEDs, these light producing compounds can be applied to more exotic and malleable surfaces. Additionally, the OLED films themselves are quite durable and can withstand a wider operating temperature range than regular LEDs without failing.

4. The price is only going down from here - The ability to simply print out OLEDs as you would a term paper or silk-screened t-shirt holds incredible technological potential. It's also ludicrously expensive at present—look to spend about triple for an OLED set than a conventional LCD/LED these days—but once roll-to-roll production capabilities are scaled up sufficiently, the cost of spitting out an OLED panel should drop below what we're paying to make current generation LEDs.

In this paper Studies of Most Common and Types of OLED and discussed the structure of them.

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